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Figs 7-8 missing

(54) Fork lift control system

(57) A control device, in a fork lift truck, comprises a sensor unit 100 including a lifting height sensor 102, a tilting angle sensor 104, and a load sensor 106. A control unit 200 has a control command producing circuit 240 with a microcomputer 230 producing a control command on the basis of comparison between unit 100 output and height data stored in the microcomputer 230.

Actuators 322, 324, including servomotor driving circuitry, respond to the command from unit 200, and a hydraulic pressure driving circuit 340 controls a lift cylinder 346 and a tilt cylinder 348 in accordance with corresponding output of each actuator.

FIG. 1

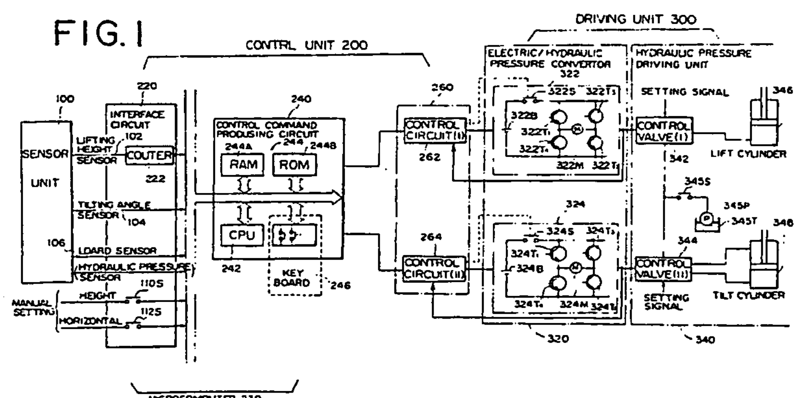

FIG. 1

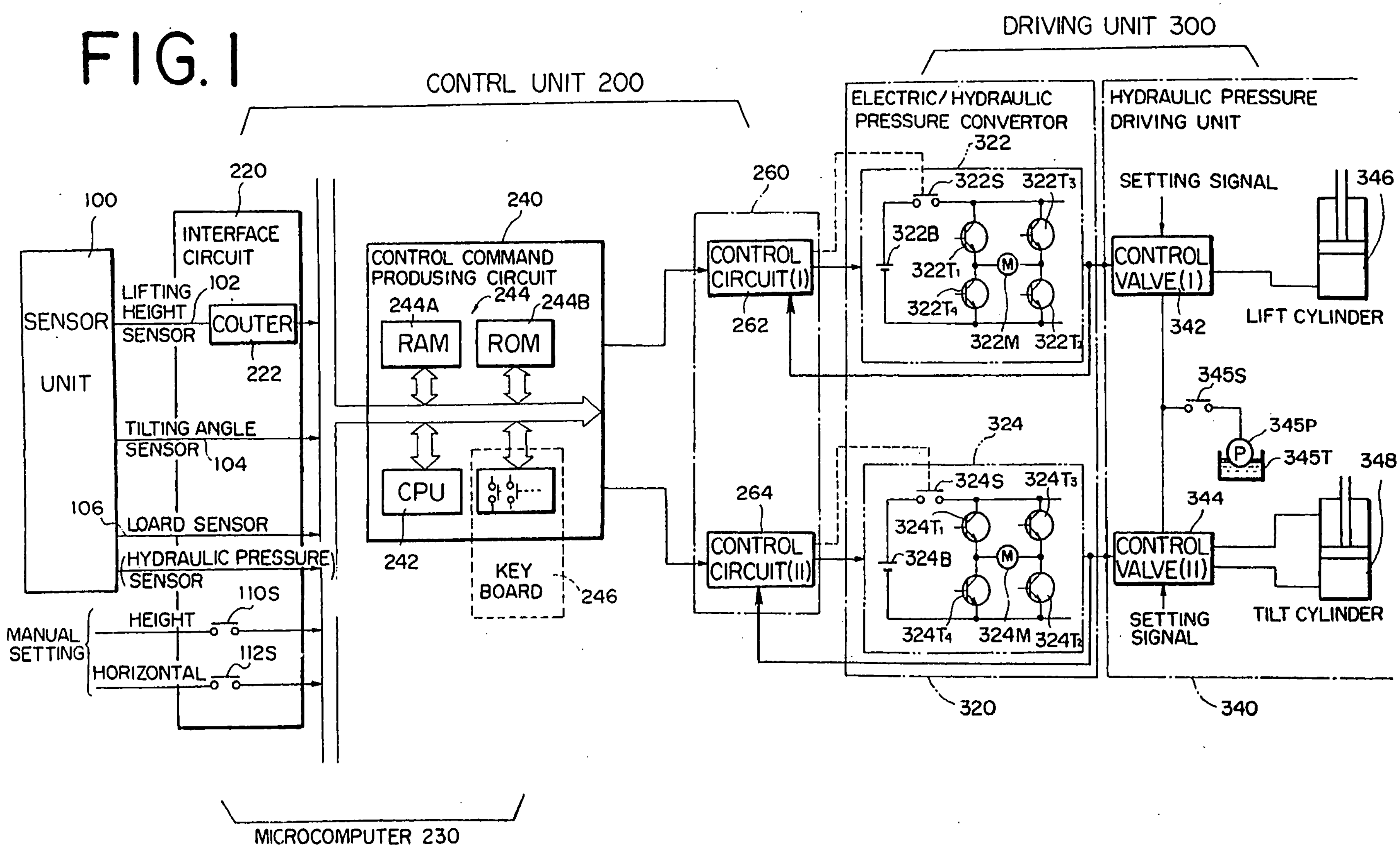
CONTRL UNIT 200
DRIVING UNIT 300
100
SENSOR
UNIT
220
INTERFACE CIRCUIT
LIFTING HEIGHT SENSOR
102
COUTER
222
TILTING ANGLE SENSOR
104
106
LOARD SENSOR
HYDRAULIC PRESSURE SENSOR
MANUAL SETTING
HEIGHT
110S
HORIZONTAL
112S
MICROCOMPUTER 230
240
CONTROL COMMAND PRODUSING CIRCUIT
244
244A
244B
RAM
ROM
CPU
242
KEY BOARD
246
260
CONTROL CIRCUIT(I)
262
CONTROL CIRCUIT(II)
264
ELECTRIC/HYDRAULIC PRESSURE CONVERTOR
322
322S
322T3
322B
322T1
322T4
322M
322T2
324
324S
324T3
324T1
324B
324T4
324M
324T2
320
HYDRAULIC PRESSURE DRIVING UNIT
SETTING SIGNAL
CONTROL VALVE(I)
342
346
LIFT CYLINDER
345S
345P
345T
348
344
CONTROL VALVE(II)
SETTING SIGNAL
TILT CYLINDER
340

FIG.2

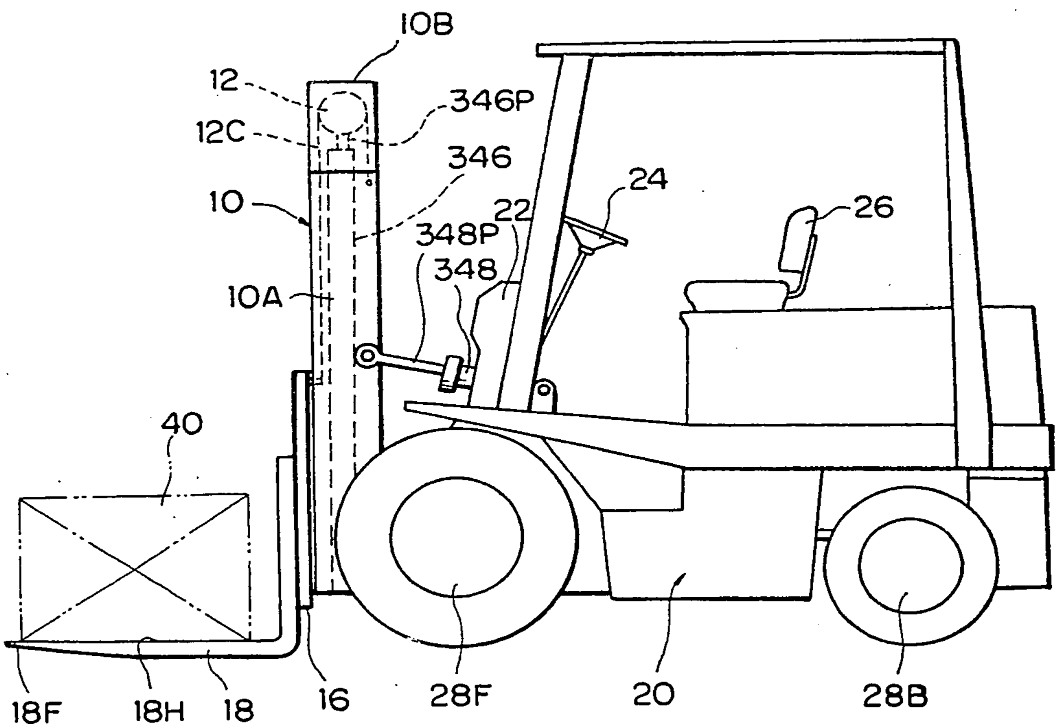
10B
12
346P
12C
346
10
24
22
26
348P
348
10A
40
18F
18H
18
16
28F
20
28B

FIG.3

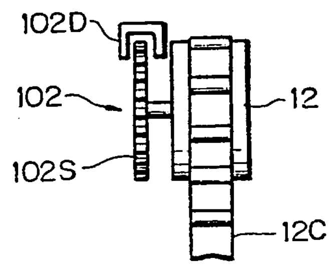

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FIG.4

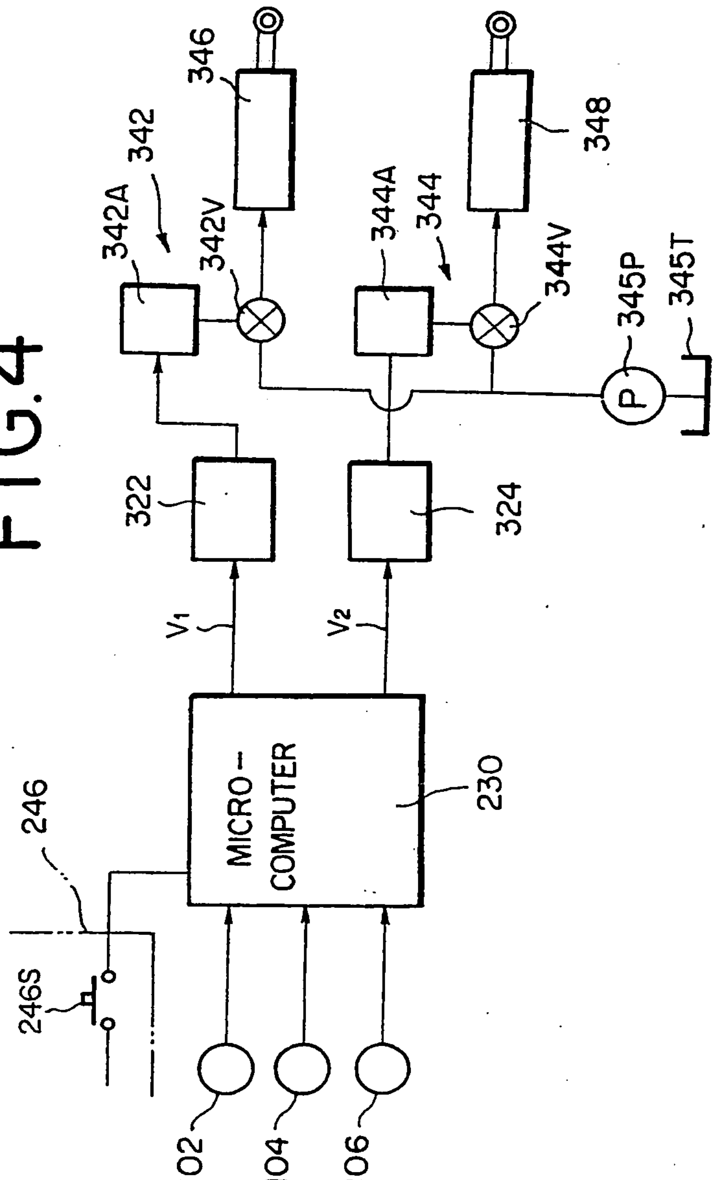
246
246S
MICRO-
COMPUTER
230
102
104
106
V1
V2
322
324
342A
342
342V
344A
344
344V
345P
345T
P
346
348

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FIG.5

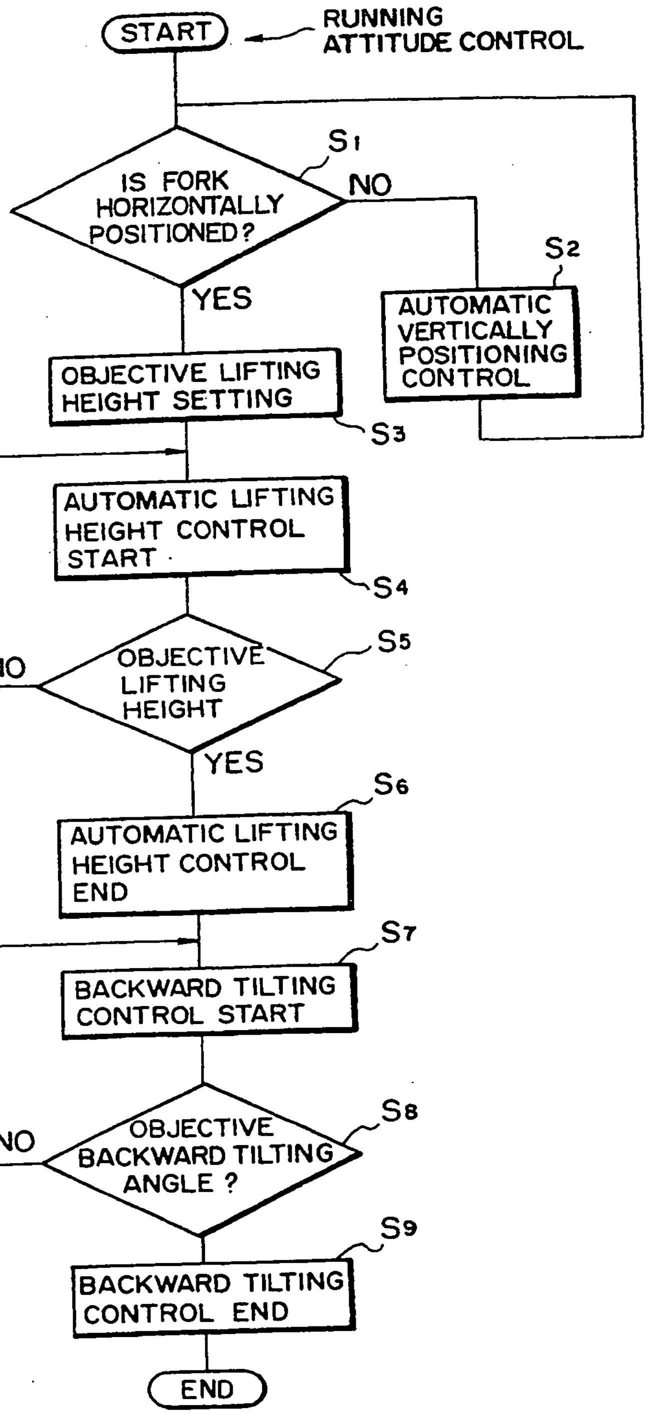

FIG.6

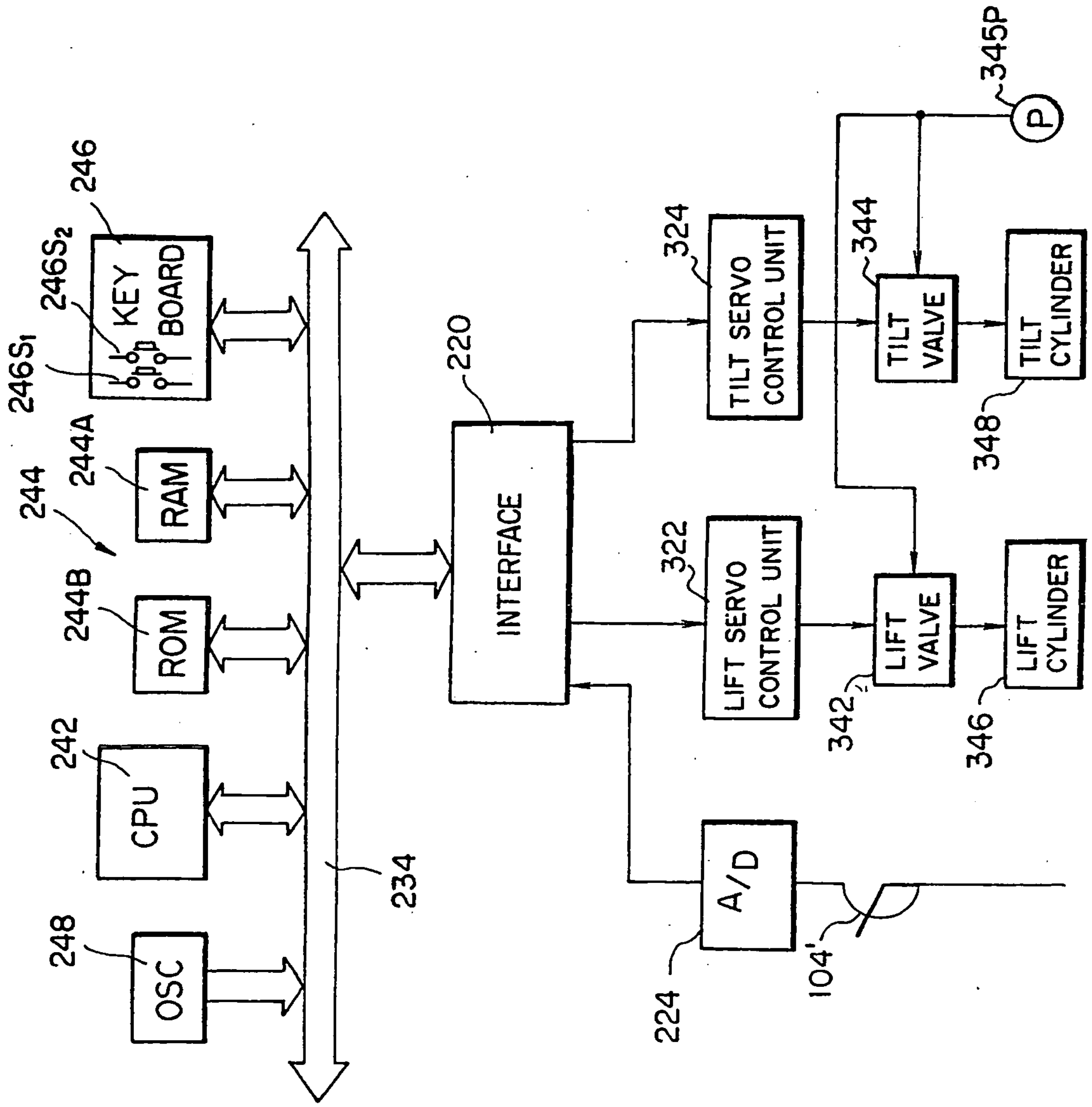
KEY BOARD
246
246S2
246S1
RAM
244A
244
ROM
244B
CPU
242
OSC
248
234
INTERFACE
220
A/D
224
104'
TILT SERVO CONTROL UNIT
324
LIFT SERVO CONTROL UNIT
322
TILT VALVE
344
LIFT VALVE
342
TILT CYLINDER
348
LIFT CYLINDER
346
P
345P

FIG.9

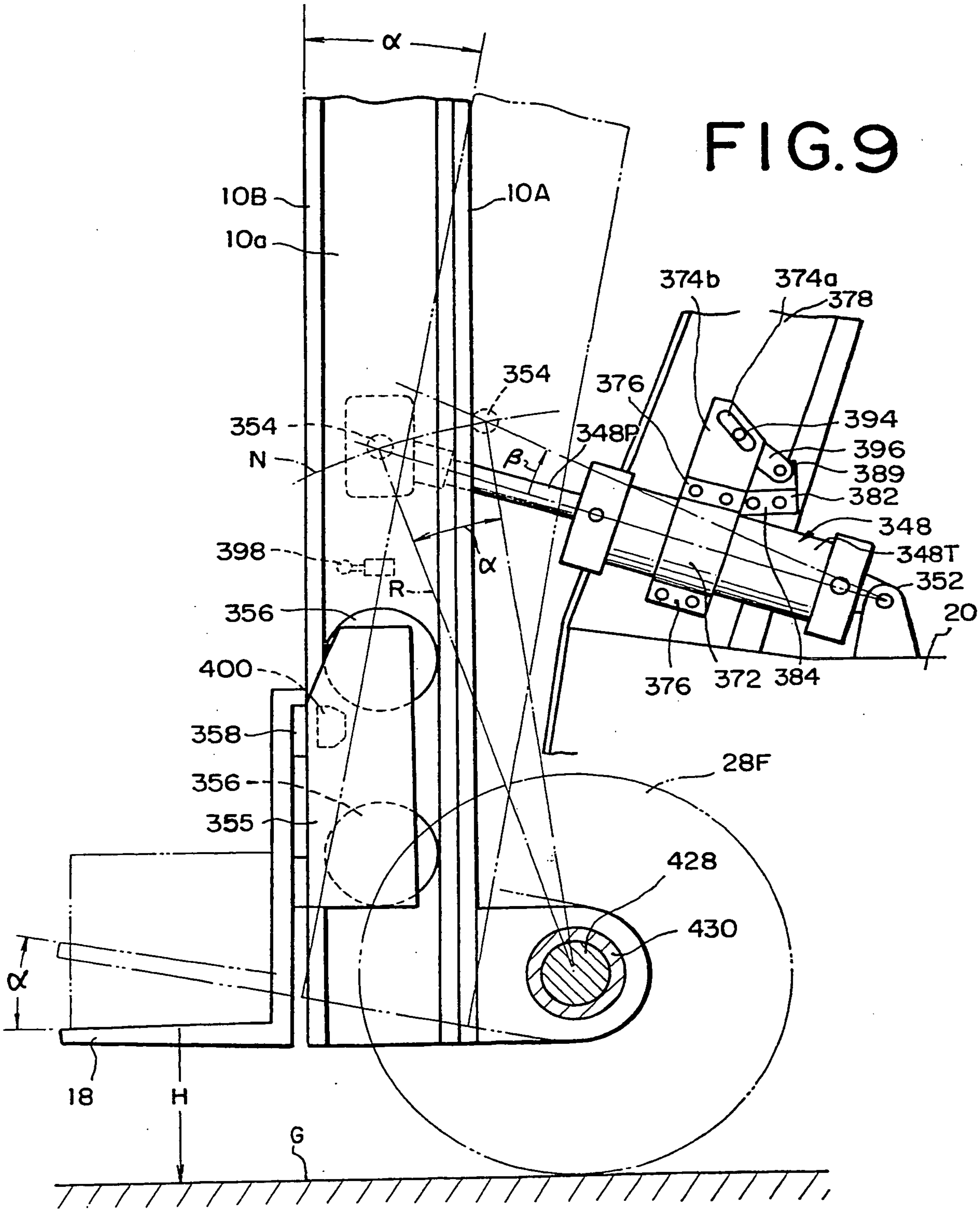
α
10B
10a
10A
374b
374a
378
354
376
394
354
348P
396
N
β2
389
382
348
398
α
348T
R
352
356
20
400
376
372
384
358
356
28F
355
428
430
α
18
H
G

FIG.10

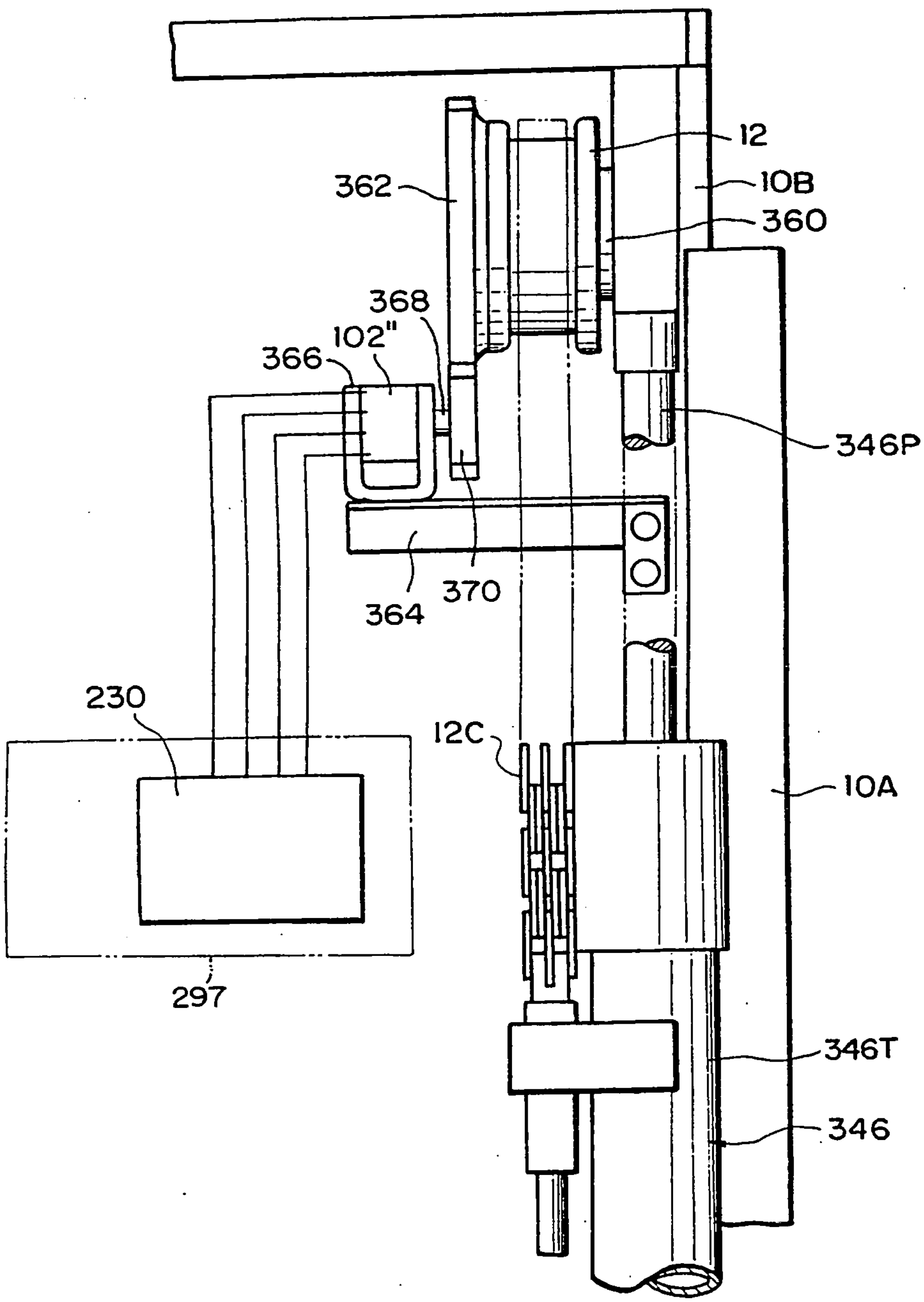

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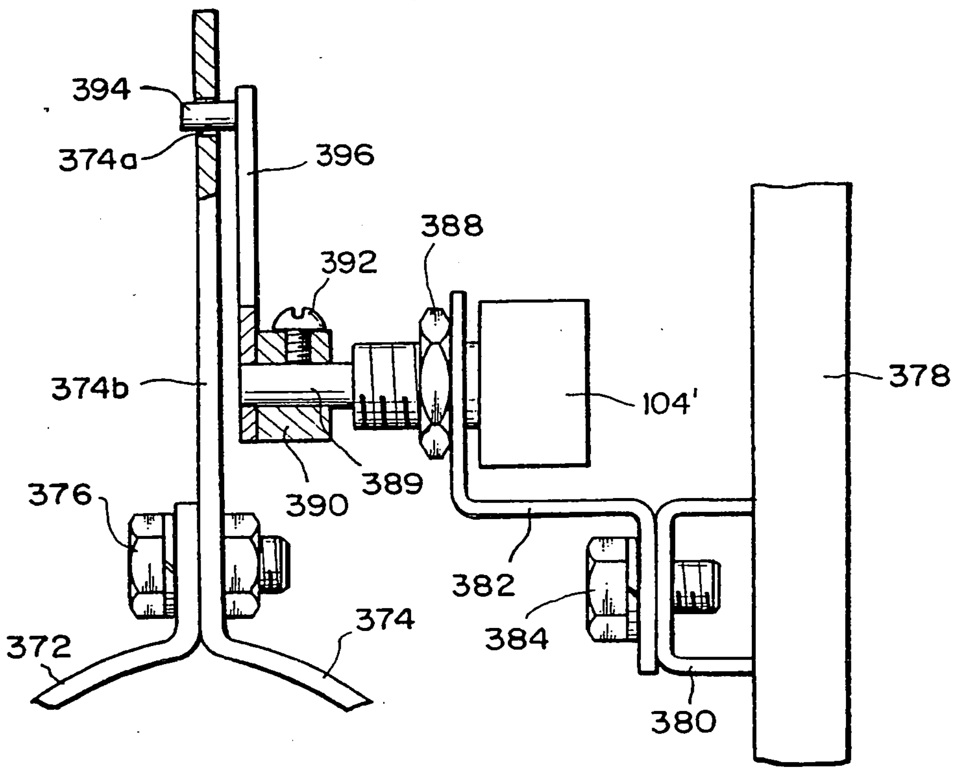
FIG.11



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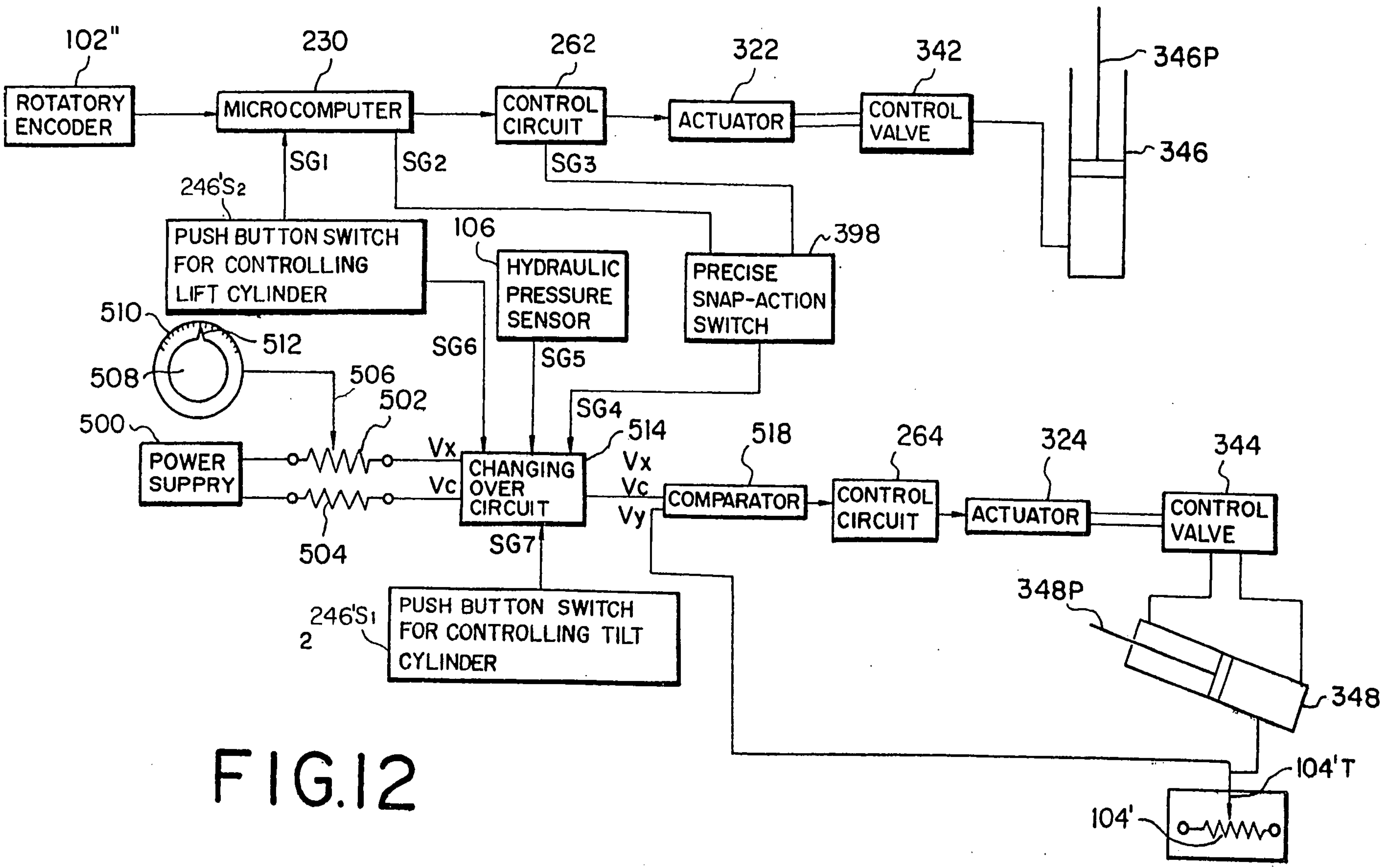

102"
ROTATORY ENCODER
230
MICROCOMPUTER
262
CONTROL CIRCUIT
322
ACTUATOR
342
CONTROL VALVE
346P
346
SG1
SG2
SG3
246'S2
PUSH BUTTON SWITCH FOR CONTROLLING LIFT CYLINDER
106
HYDRAULIC PRESSURE SENSOR
398
PRECISE SNAP-ACTION SWITCH
510
512
508
506
502
500
POWER SUPPRY
504
SG6
SG5
SG4
514
Vx
Vc
Vy
CHANGING OVER CIRCUIT
SG7
518
COMPARATOR
264
CONTROL CIRCUIT
324
ACTUATOR
344
CONTROL VALVE
348P
348
246'S1
2
PUSH BUTTON SWITCH FOR CONTROLLING TILT CYLINDER
104'T
104'

FIG.12

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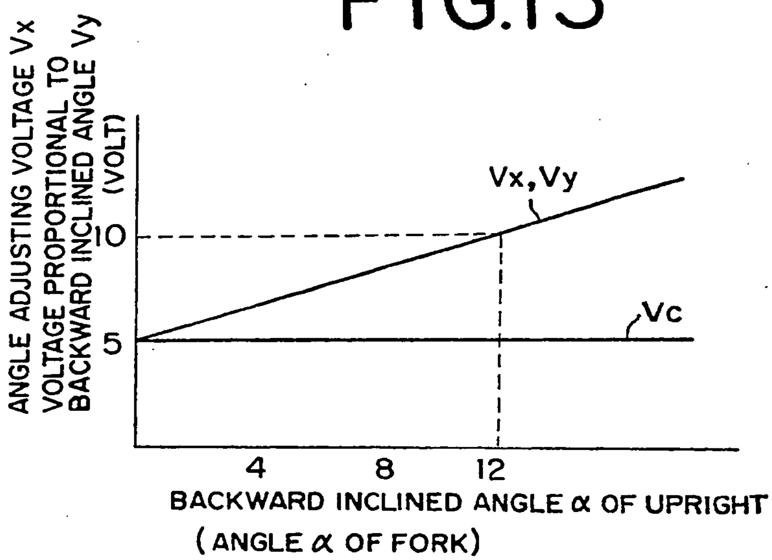
FIG.13



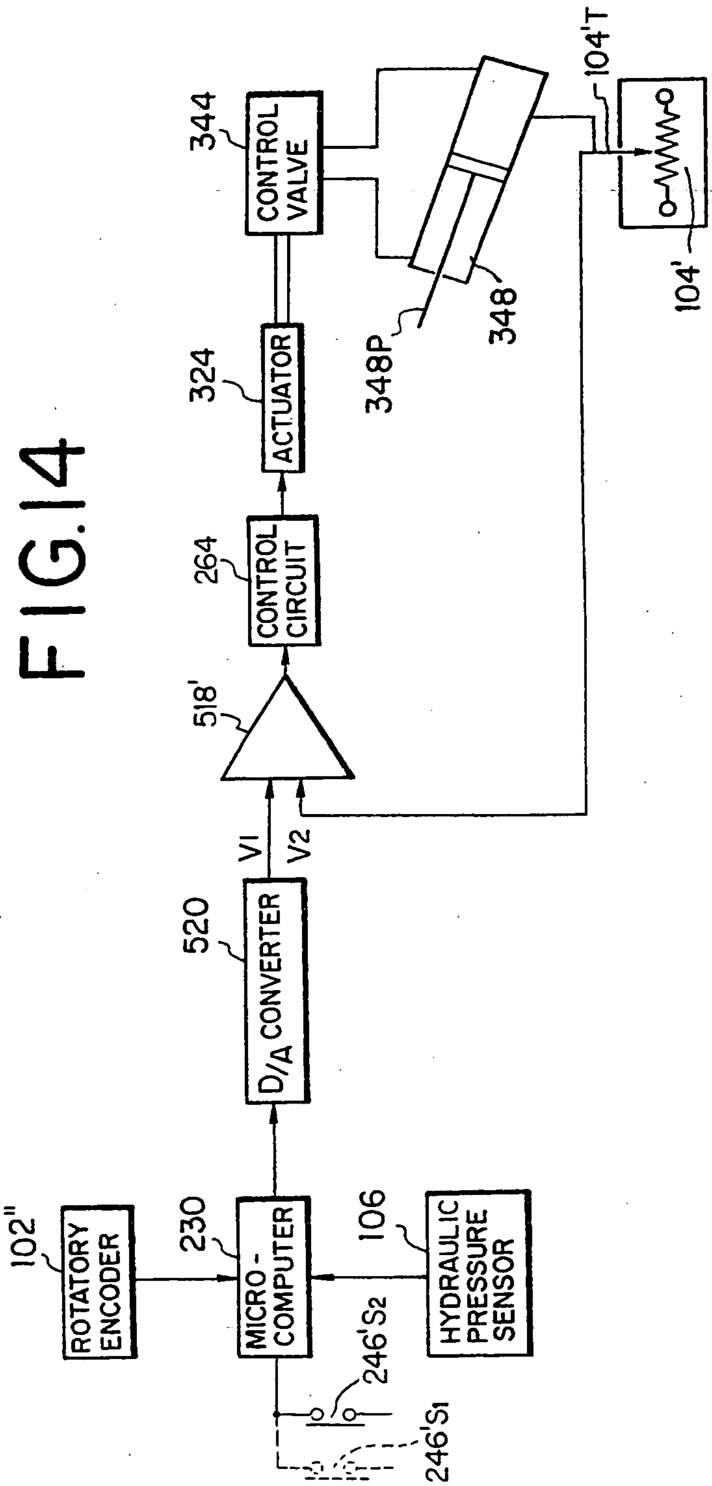

ROTATORY ENCODER
102"
MICRO-COMPUTER
230
HYDRAULIC PRESSURE SENSOR
106
246'S2
246'S1
D/A CONVERTER
520
V1
V2
518'
CONTROL CIRCUIT
264
ACTUATOR
324
CONTROL VALVE
344
348P
348
104'T
104'

FIG.14

FIG.15

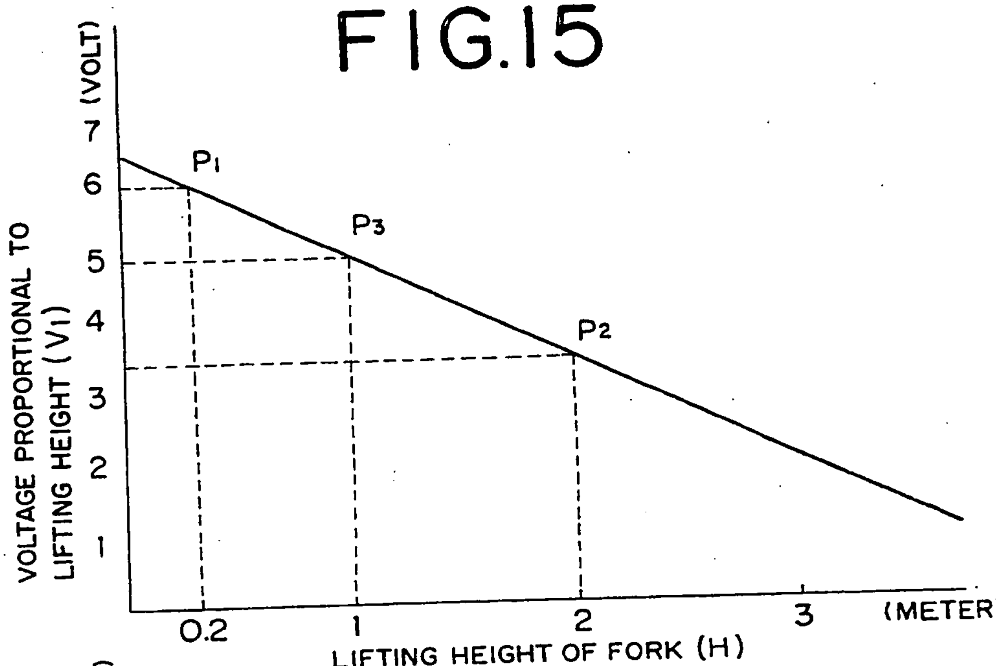
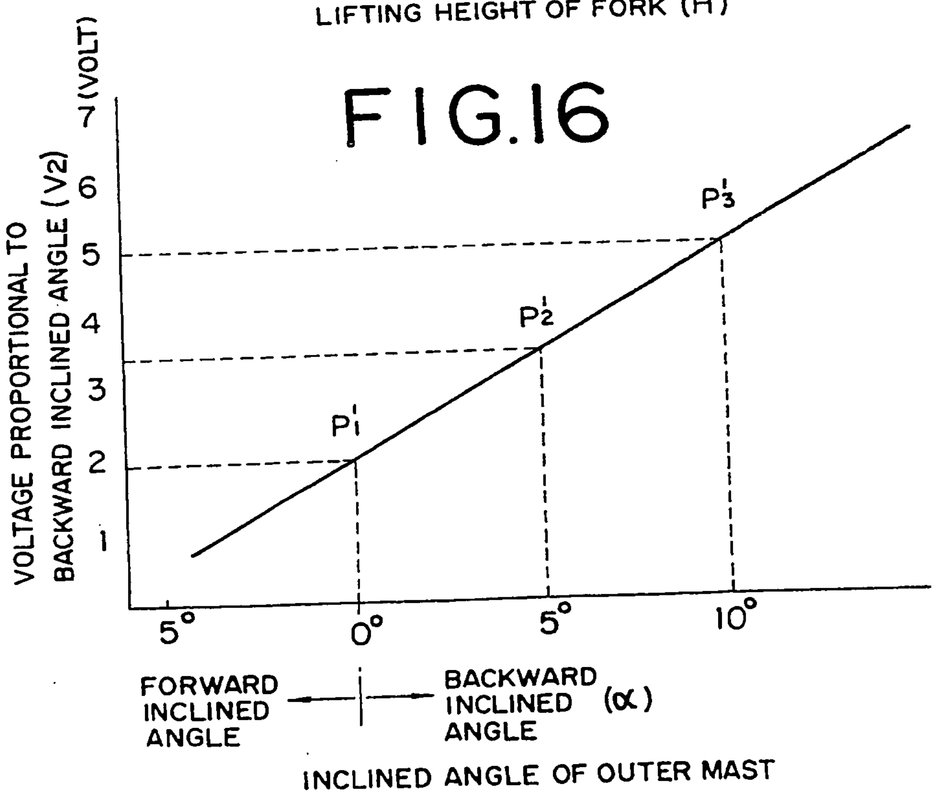

VOLTAGE PROPORTIONAL TO
LIFTING HEIGHT (V1)
(VOLT)
7
6
5
4
3
2
1
P1
P3
P2
0.2
1
2
3
(METER)
LIFTING HEIGHT OF FORK (H)

FIG.16


VOLTAGE PROPORTIONAL TO
BACKWARD INCLINED ANGLE (V2)
7 (VOLT)
6
5
4
3
2
1
P'1
P'2
P'3
5°
0°
5°
10°
FORWARD
INCLINED
ANGLE
BACKWARD
INCLINED
ANGLE
(α)
INCLINED ANGLE OF OUTER MAST

SPECIFICATION

Control device for loading and unloading mechanism

The present invention relates to a control device for loading and unloading mechanism, and more particularly to a control device for loading and unloading mechanism incorporated in a fork lift truck and effecting a running attitude control due to lifting height control of a fork or tilting angle control of an upright. Paticularly, the present invention is concerned with a control device for loading and unloading mechanism for effecting an operation for horizontally positioning a fork or running attitude operation in related to a lifting height control. Specifically, the present invention relates to a control device for loading and unloading mechanism automatically controlled in accordance with lifting height data and/or tilting angle data stored in a microcomputer.

As is well known, a fork lift truck comprises a loading and unloading mechanism and a vehicle body. The loading and unloading mechanism comprises a vertically elongated guide rail called "upright", and a fork slidable in the upright. The mechanism further comprises a hydraulic member, as for example, hydraulic cylinder for lifting and lowering the fork and tilting the upright.

In connection with the prior art loading and unloading control, for instance, lifting height control, drawback are pointed out as follows: Recently, there is a tendency that the lifting height becomes high when loading and unloading work is effected with a fork lift truck. For instance, the piling and unloading is effected at the height higher than 10m. In such a case, it is difficult for an operator to adjust the loading and unloading mechanism so that the fork is placed at the predetermined height, looking at the top of the fork positioned above about 10m relatively to the seat of the operator. Accordingly, it is desirable for the operator to easily effect piling and unloading the load at the predetermined position.

In order to embody this requirement in the prior art, the upright is provided with limit switch for stopping the fork at a predetermined position. When the fork reaches the predetermined position, for instance, 8.5m, the control device is designed so as to light a lamp provided at the operator's unit or break a driving power supply for loading and unloading work. Usually, a load is unloaded on a shelf with a plurality of steps. For this reason, in order to determine the desired position it is required to select the step. The provision of a predetermined number of limit switches, for instance, ten is required in order to meet the height of the shelf. Further, it happens that the piling and unloading is required at the other shelf according to the change of the working place. In such a case, if the height of the shelf is different from that of the prior one, more complicated control device is required. Actually, it has been impossible to effect the piling and unloading work.

Reference is made to a method for loading and unloading work. The method comprises the steps of running a fork lift truck to the position for piling a load, lifting a fork to the lifting height position, advancing the fork lift truck, mounting a load on a fork, adjusting a tilting angle of an upright in order to holizontally position the fork, and lowering the fork to the position required for safety running. The method further comprises the steps of tilting the upright in the backward direction by an angle suitable for the safety running, running the fork lift truck to the position for unloading a load, and tilting the upright in the forward direction in order to holizontally position the fork after the fork is lifted to the position required for unloading, or effect the lifting height operation of the fork and the tilting operation in the forward direction at the same time. Thereafter, the unloading operation follows in a reverse order. For a second time, the reverse operation is effected so that the fork is placed in the running attitude. The fork lift truck is returned to the position for piling.

As stated above, the prior art loading and unloading work effected with a fork lift truck requires an operation for lifting and lowering a fork, an operation for tilting an upright, and a running operation in accordance with a complicated procedure with respect to each loading and unloading work, with the result that the efficiency of the work is lowered. Further, as stated above, when a load is unloaded, the lifting height operation of the fork and the tilting angle operation of the upright are carried out at the same time or the tilting angle operation is effected and thereafter the backwardly inclining operation is effected. Accordingly, the lifting height operation is effected under the condition that the load is not placed in perfect holizontal condition, thereby to become unstable, which brings about problem in view of the safety.

Further, from the point of view of the system control in the prior art, a plurality of analog control circuits, such as, comprising combination of relay circuits respectively provided with respect to the controlled system, as for example, lifting height control are incorporated in the control unit of the control device for loading and unloading mechanism. Prior to the lifting work, an operator effects a various kinds of settings according to the lifting height condition required for loading and unloading work and then starts a lifting height work. In this instance, an automatic control system is constituted, which includes therein a valve opening control system provided with respect to a hydraulic pressure circuit for actuating a lift cylinder. The lifting height control is effected so as to control the valve opening control system due to the deviation between an actual lifting height and above said setting value. However, when the setting is changed to a great extent according to the change of the loading and unloading working place, it is r quired to adjust the automatic control system in order to stabilize the control system. Alternately, it happens that the desired control accuracy cannot be obtained. Further, such a lifting height control is effected in a series of sequential control for loading and unloading work with the lifting height control being related to various kinds of controls. Accordingly, it is desirable to supervise the whole system control in view of the simplicity of the circuit and harmonious execution of the control.

In view of this, another attempt has been made. The programmed series of sequential control matching with the objective loading and unloading work is stored in a computer, such as, microcomputer. When, for instance, lifting height control is effected, the concerned programmed routine for lifting height control is called from the program to effect a lifting height control due to the execution of the programmed routine.

In this instance, prior to lifting height work, the setting is effected by memorizing the objective lifting height into the microcomputer. When a push-button for starting an automatic lifting height is pushed, the execution of the program for lifting height control routine starts. Thus, the automatic control system including therein the above-mentioned valve opening control system becomes operative on the basis of the command being fed from the microcomputer so that the fork moves to the objective lifting height to automatically stop thereat. Accordingly, when the change of the setting is required, the changed lifting height is memorized into the microcomputer. When calling routines for lifting height control, it is sufficient to call the concerned routine in such a manner to distinguish it from the other.

These computer controlled devices for loading and unloading mechanism are provided with a pair of limit switches for setting a holizontal position of a fork and for setting an angle of running attitude of the fork responsive to the tilt cylinder for tilting the upright in the forward and backward directions along in which the fork is slidably provided. When a holizontally positioning push button switch is pushed in order to holizontally position the fork at the lifting height position in the working place, the fork is moved from inclined position to the holizontal position and is stopped thereat. When a push button switch for taking the fork to the running attitude position is pushed, the fork is moved to the predetermined position suitable for running and at the same time is rotated to the predetermined inclined position suitable for running, and is stopped thereat.

However, when the limit switch for setting an angle for running attitude becomes operative, the fork is always stopped at the predetermined inclined position. Accordingly, it is impossible to adjust the fork so that the angle of the fork suitable for kinds of the load and the shape thereof. For this reason, it is likely that this injures the load or an unstable running is compelled.

In general, as the lifting height of the loaded fork becomes high, the attitude thereof becomes unstable. However, solely the holizontally positioning of the and the running attitude thereof are controlled. As a result, it is difficult to adjust a backwardly inclined angle of the upright suitable for lifting height of the fork. If the backwardly inclined angle of the upright is set to be large, when the fork is lifted to the high lifting position, the center of the gravity of the upright becomes unstable, which brings about problem in view of safety.

With the above in mind, an object of the present invention is to provide a control device for loading and unloading mechanism making it possible to smoothly effect a loading and unloading control, such as the attitude of the fork.

Another object of the present invention is to provide a control device for loading and unloading mechanism wherein the system control is supervised by a microcomputer.

Another object of the present invention is to provide a control device for loading and unloading mechanism making it possible to automatically effect a series of sequential operation including a holizontal positioning operation after picking up of a load or piling is completed, and lifting and lowering operation thereof and tilting operation of an upright effected in order to take a predetermined running attitude, thereby facilitating the work for loading and unloading to improve a working efficiency.

Another object of the present invention is to provide a control device for loading and unloading mechanism making it possible to, prior to loading and unloading work, automatically holizontal positioning of a fork due to the execution of a program for holizontal positioning stored in a microcomputer, thereby preventing a load being falling down to improve a safety.

Another object of the present invention is to provide a control device for loading and unloading mechanism making it possible to adjust so that an angle of attitude of a fork is equal to a predetermined value during loading and unloading work due to the manual operation of a tilting angle adjusting means.

Another object of the present invention is to provide a control device for loading and unloading mechanism wherein an adjustable region for running attitude angle of a fork is narrowed according as the lifting height value of the fork becomes high, thereby making it possible to improve a safety.

According to the present invention, there is provided a control device for loading and unloading mechanism adapted to be incorporated in a fork lift truck comprising: a sensor unit including at least a lifting height sensor for measuring a lifting height of a fork and a tilting angle sensor for measuring a tilting angle of an upright, a control unit responsive to the output signal of the sensor unit, the control unit effecting a calculation on the basis of the output signal therefrom and producing a predetermined control signal according to the calculated value, a servomotor driving circuit responsive to the predetermined control signal of the control unit, and a hydraulic pressure driving circuit for lifting and lowering a fork and tilting an upright, each opening angle of valve members for actuating a lift cylinder and a tilt cylinder being adjusted in accordance with the output signal of the servomotor driving circuit, characterized in that the control unit comprises an interface circuit for inputting the output signal from the sensor unit, and a control command producing circuit comprising a memory for storing lifting height data and a tilting angle data, and a data setting means for setting the data to the memory, and in that the control command producing circuit produces a control command on the basis of comparing calculation between the output of the sensor unit and the concerned data stored in the memory to effect a desired attitude control of the fork in accordance with the control command.

The feature and advantages of a control device for loading and unloading mechanism according to the present invention will become more apparent from the description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram schematically illustrating a system construction of a control device for loading and unloading mechanism according to the present invention;

Fig. 2 is a side view illustrating a fork lift truck to which the present invention is applied;

Fig. 3 is a side view illustrating a lifting height sensor incorporated in the fork lift truck shown in Fig. 2;

Fig. 4 is a block diagram illustrating a first embodiment of a control device for loading and unloading mechanism according to the present invention;

Fig. 5 is a flow chart for effecting a running attitude control with the control device shown in Fig. 4;

Fig. 6 is a block diagram illustrating a second embodiment of a control device for loading and unloading mechanism according to the present invention;

Fig. 7A is a schematic view for explaining an automatic loading and unloading control carried out by holizontally positioning a fork and then lifting the fork in the second embodiment of the present invention;

Fig. 7B is a flow chart for effecting the automatic loading and unloading control shown in Fig. 7A;

Figs. 8A and 8B are a schematic view for explaining an automatic loading and unloading control carried out by effecting a tilting angle operation of a fork, effecting a lifting height operation of the fork, and effecting a backward tilting angle operation of the fork, and a flow chart thereof;

Fig. 9 is an enlarged side view showing a tilting angle adjusting mechanism of an upright assembled into the fork lift truck shown in Fig. 2;

Fig. 10 is a front view illustrating another embodiment of a lifting height sensor incorporated into the fork lifting truck shown in Fig. 2;

Fig. 11 is a front view illustrating an embodiment of a tilting angle sensor shown in Fig. 2;

Fig. 12 is a block diagram illustrating a third embodiment of a control device for loading and unloading mechanism according to the present invention;

Fig. 13 is a graph illustrating a relationship between a backward inclined angle of an upright and the concerned voltages in the second embodiment shown in Fig. 12;

Fig. 14 is a block diagram illustrating a fourth embodiment of a control device for loading and unloading mechanism according to the present invention;

Fig. 15 is a graph illustrating a relationship between the lifting height of a fork and a voltage proportional to the lifting height; and

Fig. 16 is a graph illustrating a relationship between the backward inclined angle and the voltage proportional to the backward tilting angle in the fourth embodiment of the invention.

Fig. 1 is a block diagram illustrating a system construction of a control device for loading and unloading mechanism according to the present invention.

Reference numeral 100 denotes a sensor unit including a lifting height sensor 102, a tilting angle sensor 104, and a load sensor 106 (hydraulic pressure sensor). Reference numeral 200 denotes a control unit comprises an interface circuit 220 including a lifting height counter 222, a control command producing circuit 240 constituted by a microcomputer 230 responsive to the output of the sensor unit 100 fed through the interface circuit 220, and a control circuit 260 responsive to the control command being from the control command producing circuit 240. Reference numerals 110S and 112S denote contacts for manual setting, which are closed by external commands indicative of lifting height and the holizontal position of the fork, respectively.

More particularly, the control command producing circuit 240 comprises a central processing unit (CPU) designated by reference numeral 242, a memory 244 essentially consisting of a random access memory (RAM) designated by reference numeral 244A, a read only memory (ROM) designated by reference numeral 244B in which predetermined lifting height, tilting angle, load, or other data are stored, and data setting means 246, as for example, comprising a key board for setting desired data by an operator. The control command producing circuit 240 produces a control command based on the output of the sensor unit 100 and the data in connection with lifting height, tilting angle, or load stored in the memory 244. The control circuit 260 comprises a first control circuit 262 for lifting height control system and a second control circuit 264 for tilting angle control system.

Reference numeral 300 denotes a driving unit comprising an electric/hydraulic pressure convertor 320 and a hydraulic pressure driving unit 340. The electric/hydraulic pressure converter 320 comprises a first and a second actuators 322 and 324 responsive to the output of the first and second control circuits 262 and 264, respectively. The first actuator 322 comprises a servomotor driving circuit (referred to later) essentially consisting of switching transistors $322T_1$ to $322T_4$ constituting an invertor for controlling a driving motor 322M, and a contact 322S for connecting a DC power supply 322B to the invertor on the basis of the command fed from the first control circuit 262, and a link mechanism (not shown) for joining the output shaft (not shown) of the driving motor 322M to a lift valve member referred to soon. Likewise, the second actuator 324 comprises a servomotor driving circuit (referred to latter) essentially consisting of switching transistors $324T_1$ to $324T_4$ constituting an invertor for controlling a driving motor 324M, and a contact 324S for connecting a DC power supply 324B to the invertor on the basis of the command fed from the second control circuit 264, and a link mechanism (not shown) for joining the output shaft (not shown) of the driving motor 324M to a tilt valve member referred to soon. The hydraulic pressure driving unit 340 comprises a first and a second control valves 342 and 344 responsive to the first and the second actuators 322 and 324, respectively. The first control valve 342 is connected to a lift cylinder 346 for controlling a lifting height while the second control valve 344 is connected to a

tilt cylinder 348 for controlling a tilting angle. Between the first and second control valves 342 and 344, there is provided a hydraulic pump 345P for supplying a suitable hydraulic oil thereto. Reference numeral 345T denotes a hydraulic oil tank. Reference numeral 345S denotes a contact provided in an electromagnetic valve (not shown) for feeding and interrupting a hydraulic oil fed from the hydraulic pump 345P in accordance with an external command. The above-mentioned first control circuit 262, the first actuator 322, the first control valve 342, and the lift cylinder 346 constitute a servo control circuit for lifting height control system. Likewise, the above-mentioned second control circuit 264, the second actuator 324, and the second control valve 344, and the tilt cylinder 348 constitute a servo control circuit for tilting angle control system.

Fig. 2 shows a fork lift truck to which the control device for loading and unloading mechanism according to the present invention is applied. Reference numeral 10 denotes a pair of uprights provided on the right and left sides, each comprising an outer mast 10A and an inner mast 10B supported by the outer mast 10A so as to move in the upper and lower directions. The lower end portion of the outer mast 10A is mounted on the front side of a truck body 20 so as to fluctuate. Reference numeral 348 denotes the above-mentioned tilt cylinder mounted to the front portion of truck body 20. A piston 348P of the tilt cylinder 348 is joined to the outer mast 10A so that the tilting angle in the forward and backward directions of the upright 10 can be adjusted. Reference numeral 346 denotes the above-mentioned lift cylinder mounted on the central portion between the pair of uprights 10, wherein the piston 346P thereof is joined to the inner mast 10B through a chain wheel supporter 10S so that the height of the inner mast 10B in the upper and lower directions can be adjusted. Reference numeral 12 denotes a chain wheel rotatably mounted on the upper end of the piston 346P. A chain 12C is fitted over the chain wheel 12. The one end of the chain 12C is joined to the outer mast 10A or the lift cylinder 346. The other end of the chain 12C is joined to a movable member 16 slidably fitted into the inner mast 10B or a fork 18 supported by the movable member 16.

Reference numeral 18F denotes a top portion or free end of the fork 18. A load designated by reference numeral 40 is mounted on a holizontal portion 18H of the fork 18. Reference numeral 24 denotes a steering wheel for an usual running. Reference numeral 26 denotes a seat for an operator. Reference numerals 28F and 28B denote a front wheel and a rear wheel, respectively.

Accordingly, when the lift cylinder 346 becomes operative, the inner mast 10B elevates. According to this movement, the fork 18 which is stretched by the chain 12C moves upwards along the inner mast 10B. As a result, a load 40 mounted on the fork 18 is lifted. Fig. 3 shows a detail of the portion with which the above-mentioned lifting height sensor 102 is associated. The lifting height sensor 102 comprises a disk 102S having a plurality of slits coaxially mounted to the chain wheel 12 and a sensor unit 102D, which may be an electromagnetic type, in the embodiment, for instance, consisting of a light source and a light detector (not shown). The slitted disk 102S rotates in accordance with the rotation of the chain wheel 12. The number of the slits is detected by the sensor unit 102D. More particularly, the sensor unit 102D produces a pulse signal corresponding to the number of the slits, thereby detecting the lifting height.

Fig. 4 is a block diagram showing a first embodiment according to the present invention, wherein the same reference numerals denote corresponding parts shown in Fig. 1 illustrating a system construction. The feature of the first embodiment resides in that a series of sequential operation including a holizontal positioning operation after picking-up of a load or piling is completed, and lifting and lowering operation of a fork and tilting operation of an upright effected in order to select a predetermined running attitude is automatically effected due to the execution of a program stored in a microcomputer.

A program for running attitude control is stored in the memory 244 (see Fig. 1) of the microcomputer 230. When a push-button switch 246S for an automatic running attitude command assembled in the key board 246 is pushed, the program is executed due to outputs of the lifting height sensor 102, tilting angle sensor 104, load sensor 106, each of which is rendered as an external input. An automatic control including a hydraulic control system for lift cylinder 346 and a hydraulic control system for tilt cylinder 348 is effected on the basis of the control commands V_1 and V_2 due to the execution of the program. The above-mentioned load sensor 106 is provided for detecting the weight of a load in order to correct the objective value required for holizontal positioning of the fork in accordance with a bending amount of the upright 10 and/or the fork 18 varying according to the weight of the load. For instance, the load sensor 106 detects a hydraulic pressure of the lift cylinder 346 and/or the air pressure of the front wheel 28F. The first control valve 342 comprises an actuator 342A and a valve unit 342V. Likewise, the second control valve 344 comprises an actuator 344A and a valve unit 344V.

Fig. 5 is a flow chart for running attitude control effected with the control device shown in Fig. 4. After a load is mounted on the fork 18 at the position for picking up a load, or a load is unloaded at the unloading position, the running attitude control starts by actuating the push-button switch 246S for entering an automatic running attitude control.

At the step S_1, the vertically positioning of the upright 10 is effected. In this instance, "upright vertically positioning" does not means that the upright 10 is vertical with respect to ground. That is, whether the holizontal portion 18H of the fork 18 is placed holizontal with respect to ground is judged (step S_1). When effecting this judgement, first of all, the tilting angle correction value is read out, which is required for placing the holizontal portion 18H of the fork 18 in the holizontal condition due to the bending of the front wheel 28F or the bending of the upright 10 and the fork 18 stored in the read only memory (ROM) 244B with respect to the load data sensed by the load sensor 106. Then, whether the holizontal portion 18H of the fork 18 is placed horizontal with respect to

ground on the basis of the tilting correction data and the inclined angle data of the upright 10 with respect to ground sensed by the tilting angle sensor 104, is judged.

When the adjustment of the inclined angle of the upright 10 is required as a result of the judgement of the step S_1, the following method is carried out. This method comprises the steps of setting a tilting angle objective value of the upright 10 calculated by effecting an addition and/or a reduction between the tilting correction value and the inclined angle data of the upright 10, and entering an automatic vertically positioning control (step S_2) for automatically controlling the tilt cylinder 348 so as to reach the setting value.

The holizontal control of the fork 18 is effected based on the automatic vertically positioning control. Upon completion of this control, in order to lower the fork 18 to the height (for instance, 30 cm above ground) appropriate for running, the lifting height data is read out from from ROM 244B as shown in the step S_3. The program execution is entered into an automatic lifting height control (step S_4) for automatically controlling the lift cylinder 346 under the condition that this lifting height data is the objective value for effecting a lifting height control, and the output of the lifting height sensor 102 is feedback value as shown in the step S_4. The judgement as to whether the fork 18 is lowered to the objective height suitable for running by the automatic lifting height control is effected at the step S_5. Thus, when the lifting height of the fork 18 is equal to the objective lifting height, the program execution is entered into the automatic lifting height stopping control (step S_6).

After the predetermined lifting height control of the fork 18 is completed, the backward tilting control of the upright 10 is required so that the load 40 is not slipping or falling down even in the sudden starting or breaking. As shown in the step S_7, the program execution is entered into an automatic backward tilting angle control for automatically controlling the tilt cylinder 348 under the condition that the backward tilting angle data read from the memory 244, for instance, ROM 244B is an objective value, and the output of the tilting angle sensor 104 is a feedback value. When the upright 10 (the fork 18) is placed in the predetermined backward tilting angle position (step S_8) by the automatic backward tilting angle control, the automatic backward tilting control is completed (step S_9). Thus, the automatic running attitude control is completed.

The control device according to the first embodiment of the present invention makes it possible to smoothly effect a control from the piling or unloading operation to the running attitude control solely by the actuation of the switch 246S for effecting an automatic running attitude. That is, the horizontal portion 18H of the fork 18 is controlled so that it is placed in holizontal condition. Then, the fork is lifted or lowered to the predetermined position suitable for running. Finally, the backward tilting control is effected so that the backward inclined position is suitable for running. Thus, this makes it possible to remarkably lessen the burden for an operator.

Further, the control according to the present embodiment in which the variation or deviation with respect to the holizontal position of the fork 18 due to the weight of the load is taken into account, is effected, thereby improving the safety to increase the working efficiency.

Reference is made to the second embodiment of the invention.

When loading and unloading work is effected with a fork lift truck, the work is classified into two operational modes. One is to tilt the upright 10 in the forward and backward directions with the tilt cylinder 348. The other is to lift or lower the fork 18 with th lift cylinder 346. For instance, when picking up the load from a shelf to move it to another place, that is, when effecting a piling work, it is required to run the fork lift truck under the condition that the upright 10 is placed in the predetermined backwardly inclined condition where the upright 10 is inclined from the position having an angle of Θ_0 to the position having an angle of Θ_1, as shown in Fig. 2. Accordingly, when the loaded fork lift truck reaches the shelf at which the load is to be transferred, after the angle of the upright is altered from the position of the angle Θ_1 to the position of the anlge Θ_0 for a second time, it is required to mount the load on the shelf.

At this time, assuming that the angle of the upright 10 and the lifting height of the fork 18 are varied from the condition that the inclined angle is Θ_1 and the lifting height of the fork 18 is h_1 to the condition that the inclined angle is Θ_0 and the lifting height of the fork 18 is h_2. In the prior art, as stated above, the backward tilting angle control and the lifting height control are effected at the same time. Alternately, after the lifting height control is effected, the backward tilting angle control is effected. As a result, the load is placed in an unstable condition, which brings into dangerous condition.

The second embodiment has solved these problems. The feature of the present embodiment r sides in that when a load is mounted on a shelf, the actuation of the lift cylinder is effected solely when the fork is placed in holizontal condition, while when a load is picked up from a shelf and is removed to other place, the same action is effected solely when the fork is placed in a holizontal position or backwardly inclined position.

Fig. 6 is a block diagram illustrating a circuit construction for embodying the second embodiment, wherein the same reference numerals denote corresponding elements of Fig. 1, respectively. Reference numeral 248 denote an osicllator for clock signal, although not shown in Fig. 1.

A microcomputer system is constituted by CPU 242, memory 244, key board 246, oscillator 248, interface 220. In this system, the data transfer is effected through bus 234 under the governed condition by CPU 242 in accordance with the clock signal. In the embodiment, the tilting angle of the tilt cylinder 348 is sensed by a potentiometer 104'. The sensed analog data is converted into digital data by A/D converter and is fed to the interface 220. The lift servo control unit (first actuator) 322, lift valve 342, and lift cylinder 346 constitutes a servo driving circuit for lifting height control system. The tilt servo

control unit (second actuatory) 324, tilt valve 344, and tilt cylinder 348 constitutes a servo driving circuit for tilting angle control system.

In operation, at the time of picking up the load from a shelf to the other shelf, there occurs forward inclination for the following reasons: One is that the load is mounted on the fork 18 under the condition that the forward tilting angle of the upright 10 is, for instance, Θ_2 shown in Fig. 2. Second is that the load mounted on the fork 18 becomes unbalanced due to the discrepancy of the joint between the inner mast 10B and the outer mast 10A. Prior to the loading and unloading operation, the operator presses the push button switch $246S_1$ for controlling tilt cylinder 348 provided on the key board 246. As a result, the signal is fed to the CPU 242. The CPU 242 instructs to execute the program for horizontal operation of the fork 18 (the vertical operation of the upright 10) to the ROM 244B. At the same time, CPU 242 instructs the interface 220 so that the output signal of the potentiometer 104' is fed thereinto. At this time, the output signal proportional to the tilting angle from the potentiometer 104' is converted to a digital signal by the A/D converter 224 in accordance with the instruction. The output of the A/D converter 224 is fed to CPU 242 through the interface 220. The CPU 242 designates an address of RAM 244A to store it therein. The result is stored in CPU 242 for a second time. When the upright 10 is placed in forward inclined condition, CPU 242 feeds a control signal for returning the position of the upright 10 in the horizontal direction to the second actuator 324 through the interface 220. Thus, the upright 10 is controlled in the direction that it is pulled out by the tilt cylinder 348 through the tilt valve 344. The output of the potentiometer 104' varies with time proportional to the inlined angle of the upright 10. As stated above, the value is written into RAM 244A. When the accumulated result of RAM 244A is equal to the value previously set, CPU 242 produces a command for stopping the output which is fed to the second actuator 324 to the interface 220 to stop the operation of the tilt cylinder 348.

Thus, the horizontal portion 18H of the fork 18 is placed in a holizontal position as shown by a solid line in Fig. 7A. The above-mentioned control is indicated by steps S_1 and S_2 in Fig. 7A. When the operator presses the push-button switch $246S_2$ provided on the key board 246, the lift cylinder 346 is controlled in the direction that the piston rod (not shown) thereof is reduced shown by the step S_3 in Fig. 7B through the interface 220, the first actuator 322, the lift valve 342 on the basis of the program stored in ROM 244B. As a result, the fork 18 on which the load 40 is mounted is holizontally maintained at the predetermined running position. Accordingly, the fork 18 is controlled in the lowering direction so that the load 40 is held horizontal and is placed in a stable condition, with the result that there no occurs that the load slips or falls down.

In order to bring the load 40 from the running position to the other shelf, the fork 18 is controlled by the servo control circuit for tilting angle control system so that the tilting angle thereof is equal to the predetermined angle, for instance, Θ_1 as shown in Fig. 2. The control, in this instance, is effected as indicated by the steps S_4 and S_5 in Fig. 7A. The maximum backwardly inclined position is shown by a broken line in Fig. 7A. Thus, the running attitude control is completed.

When picking up the load from the shelf, if the fork 18 is placed in backwardly inclined position, the program execution is directly shifted to the operation for lowering the lift cylinder 346 as shown in the step S_3. In the above-mentioned embodiment, it is described that after horizontally positioning operation is completed, the operator actuates the push-button switch $246S_2$ for actuating the lift cylinder 346 thereby to effect an operation of the lift cylinder 346. If a program for controlling the operation of the lift cylinder 346, which shifts in the lowering direction from the position of the fork 18, at which the load is picked up from the high position shelf, to the lower position of predetermined height is stored in ROM 244B, a sequential control including the horizontally positioning operation of the fork 18 and the lowering operation thereof can be effected solely by pressing the push-button switch $246S_1$ provided on the keyboard 246.

It is now assumed that the load 40 is conveyed under the backwardly inclined condition, as shown by a solid line in Fig. 8A, and then the load 40 is mounted on a shelf positioned above as shown by a dotted line in the same figure. In such a case, the procedure for effecting holizontal operation of the fork and the lifting height operation of the fork can be automatically effected due to the actuation of the push-button switch $246S_1$. The procedure in this instance is shown in Fig. 8B.

According to the second embodiment of the invention, when the push-button switch $246S_1$ for holizontally positioning is pushed, the fork on which a load to be lifted or lowered is mounted can be placed in a holizontal condition. Accordingly, there no occurs that the lifting and lowering of the load is effected in the unstable condition, thereby enabling to effect a loading and unloading work in a safety. Further, there no occurs that the load is injured due to slipping or falling down thereof. Further, whole loading and unloading work can be automatically effected by programming a series of sequential operation including holizontally positioning operation and lifting height operation.

Reference is made to the third embodiment of the present invention. The feature of the present embodiment resides in that when a running attitude control is effected, the sensing voltage of the tilting angle adjusting means is compared with the voltage proportional to the backwardly inclined angle of the upright so that the lifting angle of the fork is adjustable according to the kinds of loads and the shape thereof, and when the former is equal to the latter, the operation of the tilt cylinder for tilting the upright is stopped.

At the front end of the vehicle body 20, as shown in Fig. 9, an axle supporting sleeve 430 for supporting a supporting axle 428 of the front wheel 28F is fixed. The outer mast 10A is supported at the lower end portion thereof on the axle supporting sleeve 430 so that it is inclined in the forward and backward

directions. The root of the cylinder body 348T of the tilt cylinder 348 is joined by means of a connecting pin 352 on the upper surface of the vehicle body 20 so as to rotate in the upper and lower directions. The top of the piston 348P of the tilt cylinder 348 is to the outer side surface of the outer mast 10A joined by means of a connecting pin 354 so as to tilt the outer mast 10A in the forward and backward directions.

Assuming that, as an initial condition, the outer mast 10A is placed in the vertical position as shown by solid line shown in Fig. 9. If the piston 348P of the tilt cylinder 348 is withdrawn, the outer mast 10A is rotated in the backward direction with the supporting axle 428 being as a center. As a result, the connecting pin 354 is rotated backward by an angle of α drawing a circular locus N with the radius of R. The tilt cylinder 348 is rotated by an angle of β with the connecting pin 352 being the center thereof according to a rotational angle α of the connecting pin 354, that is, the backwardly inclined angle α of the upright 10.

The inner mast 10B is mounted, as shown in Fig. 10 inside of the outer mast 10A so that it moves in the upward and downward directions. A lift bracket 355 is mounted, as shown in Fig. 9, in the inner recess 10*b* of the inner mast 10B through a guide roller 356 so that it elevates and lowers. A pair of finger bars 358 for supporting the fork 18 is mounted at the front edge of the bracket 355. The chain wheel 12 (see Fig. 3) is supported at the inside of upper portion of the inner mast 10B, as shown in Fig. 10, by a pivotal axle 360. The intermediate portion of the lift chain 12C, one end of which is joined to the upper portion of the cylinder body 346T of the lift cylinder 346 while the other end thereof is joined to the lift bracket 355.

Accordingly, when the piston 346P of the lift cylinder 346 is moved in the upper and lower directions, the inner mast 10B and the chain wheel 12 are moved in the upper and lower directions. As a result, the lift bracket 355 is moved in the upper and lower directions by the lift chain 12C, so that the fork 18 moves in the upper and lower directions at a speed which is twice that of the inner mast 10B. At this time, the chain wheel 12 is rotated by the lift chain 12C proportional to the moving distance in the upper and lower directions of the fork 18.

As shown in Fig. 10, a large sized toothed wheel 362 is fixed to the side surface of the chain wheel 12C. A supporting arm 364 is supported in a holizontal fashion at rear surface of the inner mast 10B so as to position downwardly of the large sized toothed wheel 362. A rotary encoder 102" serving as the lifting height sensor 102 is fitted over the supporting arm 364 through a U-shaped mounting metal fitting 366. A small sized toothed wheel 370 meshing with the large sized toothed wheel 362 is fitted over an input axle 368 of the rotary encoder 102". When the input axle 368 is rotated in the forward and backward directions, the rotary encoder 102" produces at the same time two kinds of pulses, one having a phase different from that of the other, for calculating the lifting height value.

A detecting mechanism for detecting a backwardly inclined angle α of the outer mast 10A will be described with reference to Figs. 9 and 11. A pair of semi-circular mounting bands 372 and 374 are clamped along the outer periphery of the cylinder body 348T of the tilt cylinder 348 by means of a bolt 376. An operating portion 374*b* with an elongated bore 374*a* is constituted by extending the upper end portion of the mounting band 374 in the upper direction.

On the other hand, a U-shaped base metal fitting 380 is welded to the one side of an instrument panel 378 projected on the upper surface of the vehicle body 10, as shown in Fig. 11, so as to correspond to the operating portion 374*b*. A supporting plate 382 shaped as shown in Figure is supported on the left side surface of the metal fitting 380 by means of a bolt 384. A potentiometer 104' is clamped to the supporting plate 382 by means of a nut 388. A mounting boss 390 is clamped to a movable terminal 389 of the potentiometer 104' by means of a screw member 392. An arm 396 is provided with a root portion fitted to the mounting boss 390, and a free end portion on which a pin 394 is provided. The pin 394 is fitted into an elongated bore 374*a* of the operating portion 374*b*. In this embodiment, the outer mast 10A is inclined backwardly by the tilt cylinder 348. When the tilt cylinder 348 is rotated in the clockwise direction in Fig. 9 with a connecting pin 352 being as the center of the rotation, the operating portion 374*b* is moved upwardly together with the cylinder body 346T. As a result, the movable terminal 389 of the potentiometer 104' is rotated through the pin 394 and the arm 396. The output voltage of the potentiometer 104' (called "the voltage proportional to the backwardly inclined angle hereinafter, which is the same meaning as that of the voltage proportional to the angle of the fork 18) increases in proportion to the backwardly inclined angle α of the outer mast 10A, as shown in Fig. 13.

An automatic running attitude control device and an automatic holizontally positioning control device according to the third embodiment of the invention will be described with reference to Fig. 12.

The microcomputer 230 is assembled in an operating box 397 provided in the operator's seat (see Fig. 2) of the fork lift truck. The microcomputer 230 judges as to whether the fork 18 is lifting or lowering in accordance with the two kinds of pulses, one having a phase different from that of the other, fed from the rotary encoder 102", and calculates the lifting height value of the fork 18 to indicate it on a suitable display.

A precision snap-acting switch 398 is mounted on an external side surface of the outer mast 10A. The precision snap-acting switch 398 is provided for setting the lifting height H of the fork 18 with respect to ground G to the predetermined height (for instance, 33 cm) suitable for running, as shown in Fig. 9. In relation to the precision snap-acting switch 398, a dog 400 is engaged with the one side of the inner mast 10B. When the lifting height H of the fork 18 reaches the predetermined height (e.g. 33 cm), the precision snap-acting switch 398 is actuated by the dog 400. Thus, a reset signal SG, for resetting so that the lifting height of the fork 18 is 33 cm, is fed to the microcomputer 230.

A push-button switch $246S_2$ for controlling the lift cylinder 346 is provided on the upper surface of the operating panel (not shown) of the operating box 397. When the push-button switch $246'S_2$ is pressed, a command signal SG_2 for lifting and lowering the fork is fed to the microcomputer 230. When the lifting height H of the fork 18 is below the predetermined height (33 cm) suitable for running, a command signal for rotating in the forward direction is fed to the first control circuit 262 connected to the actuator 322 which operates the control valve 262 for hydraulically controlling the lift cylinder 346 from the microcomputer 230. When the fork 18 is above the predetermined height, the microcomputer 230 feeds a command signal for rotating in the backward direction to the control circuit 262. Further, when the fork 18 is moved to the predetermined height, whereby the precision snap-acting switch 398 is actuated by the dog 400, a stopping command signal SG_3 is fed to the control circuit 262 from the precision snap-acting switch 398.

Reference numeral 502 denotes a variable resistor for producing a voltage Vx for adjusting an angle so that the holizontal portion 18H of the fork 18 is suitable for running according to kinds and the shape of the load. Reference numeral 504 denotes a fixed resistor for producing a constant voltage Vc (e.g. 5 volt in Fig. 13 embodiment) for setting that the fork 18 is placed in holizontal condition. These are connected in parallel with a DC power supply 500. The variable resistor 502 is incorporated in the operating box 397. The movable terminal 506 thereof projects on the upper surface of the operating panel of the box 397. An adjusting knob 508 for adjusting the angle of running attitude of the fork 18 is fitted to the movable terminal 506. An indicator 512 for indicating the angle of the fork provided on the upper surface of the operating panel is fitted to the knob 508 in relation to the scale 510 for showing angle. In the embodiment, when the adjusting knob 508 is rotated in the direction that the angle of the fork is large as shown in Fig. 13, the voltage Vx for adjusting the angle of the fork increases together with the voltage Vy proportional to the inclined angle.

A change-over circuit 514 is connected to the variable resistor 502 and the fixed resistor 504. The command signal SG_4 indicating the changing of the circuit fed from the precision snap-acting switch 398 is fed to the change-over circuit 514. The changing command signal SG_5 fed from a pressure sensor 106 which is provided in a hydraulic pressure circuit and becomes operative when the hydraulic pressure is above the predetermined value, that is, the weight of the load mounted on the for 18 is above the predetermined value, is fed to the change-over circuit 514. Further, the change-over command signal SG_6 is fed to the change-over circuit 514 when the push-button switch $246S_2$ for automatic running attitude of the fork becomes operative. The change-over circuit 514 is changed to the variable resistor 502 to produce a voltage Vx for adjusting the angle of the fork from the changing circuit 514 when solely the following conditions are held:

One condition is that the fork 18 is moved to the predetermined height (33 cm), so that the precision snap-acting switch 398 becomes operative.

Second condition is that the pressure sensor 106 becomes operative, so that three changing command signals SG_4 to SG_6 are fed to the change-over circuit 514.

The change-over circuit 514 is designed so that the changing command signal SG_7 is fed thereto when the push-button switch $246'S_1$ for controlling tilt cylinder provided on the operating box 398 is switched on. When the push-button switch $246S_1$ is actuated so that the change-over circuit 514 is changed to the fixed resistor 504, a constant voltage Vc for placing the fork in the horizontal condition is fed from the change-over circuit 514.

A comparator 518 capable of feeding the stop command signal indicative of forward and backward rotation to the second control circuit 264 of the second actuator 324 for operating the control valve 344 of the tilt cylinder 348, is connected to the potentiometer 104' and the change-over circuit 514. When the angle setting voltage Vx or the constant voltage Vc is fed from the change-over circuit 514, the compatator 518 compares the voltage Vx (or Vc) with the voltage Vy proportional to the backwardly inclined angle fed from the potentiometer 104'. When the voltage Vy is larger than the other voltage Vx (or Vc), that is, the actual angle of the fork is larger than the objective angle thereof, the forward rotating command signal is fed from the comparator 518, with the result that the outer mast 10A is rotated in the forward direction (in the direction that the voltage Vy becomes small) by the tilt cylinder 346. Further, when the voltage Vy is equal to the other voltage Vx (or Vc), the stop command signal is fed from the comparator 518 so that the tilt cylinder 348 is stopped.

On the contrary, when the voltage Vy is smaller than the voltage Vx (or Vc), that is, the actual angle of the fork is smaller than the objective angle thereof, the reverse rotating command signal is fed from the comparator 518 so that the outer mast 10A is rotated backward (in the direction that the voltage Vy becomes large) by the tilt cylinder 348.

The voltage Vy proportional to the inclined angle is always applied to the comparator 518 from the potentiometer 104'. The comparator 104' becomes operative solely when the voltage Vx or Vc is applied thereto.

The operation of the automatic running attitude control device and the automatic horizontal control device for a fork thus constructed will be described.

Fig. 9 shows that the fork 18 is stopped at the position lower than the predetermined height (33 cm), the masts 10A and 10B are placed in a vertical condition (the angle of the fork is zero), the inclined angle proportional voltage Vy fed from the potentiometer 104' is 5V, and a suitable load is mounted on the fork 18. Prior to the operation for moving the fork 18 from such a condition to the desired running attitude position, the adjusting knob 508 is actuated so that the indicator 512 thereof is set to the objective angle (for instance, 12 degree) of the scale 510 showing the angle of the fork, and the angle adjusting voltage Vx of 10 volt corresponding to the objective angle is fed to the change-over circuit 514 from the variable

resistor 502.

When the push-button switch 246'S_2 for controlling lift cylinder is pressed, the command signal SG_2 for lifting and lowering is fed to the microcomputer 230. The command signal for rotating in the forward and backward directions is fed to the control circuit 262 from the microcomputer 230, with the result that the fork 18 is moved upwards by the lift cylinder 346. When the lifting height H of the fork 18 reaches the predetermined height (33 cm), the precision snap-acting switch 398 is actuated by the dog 400. As a result, the reset signal SG_1 is fed to the microcomputer 230 from the precision snap-acting switch 398. As a result, it is indicated that the lifting height of the fork 18 is 33 cm. On the other hand, the stop command signal SG_3 for lift cylinder is fed to the control circuit 262, with the result that the fork 18 is stopped at the predetermined height. At the same time, three changing command signals SG_4 to SG_6 are fed to the change-over circuit 514. As a result, the change-over circuit 514 is connected to the variable resistor 502. As a result, the angle adjusting voltage Vx of 10 volt previously set is fed to the compatator 518 from the change-over circuit 514. The compatator 518 compares the voltage Vx of 10 volt with the voltage Vy of 5 volt from the potentiometer 104'. In this instance, since the voltage Vx is larger than the voltage Vy, the comparator 518 produces the inversing rotation command signal. As a result, the outer mast 10A is inclined backwardly by the tilt cylinder 348. According to this action, the movable terminal 104'T of the potentiometer 104' is rotated so that the voltage Vy becomes large. When the voltage Vy is equal to 10 volt which is the same voltage as that of the voltage Vx, the comparator 518 produces a stop command signal. As a result, the tilt cylinder 348 is stopped. Thus, the fork 18 is stopped at the inclined position of 12 degree of the objective angle.

On the other hand, assuming that the fork 18 is a predetermined lifting height position and is inclined at a constant angle, and the backward inclined proportional voltage Vy is above 5V. In such a condition, when the push-button switch 246S_1 for controlling tilt cylinder is pressed in order to place the fork 18 in the holizontal position, the changing signal SG_7 is fed to the change-over circuit 514. As a result, the circuit 514 is connected to the fixed resistor 504. The circuit 514 produces a constant voltage Vc of 5 volt. Thus, the comparator 518 compares the voltage Vy with the voltage Vc. Since the voltage Vy is larger than the constant voltage Vc, the comparator 518 produces a command signal indicative of forward rotation. As a result, the fork 18 is rotated toward the holizontal position. When the voltage Vy is equal to the constant voltage Vc, that is, 5V, the fork 18 is stopped at the holizontal position.

Thus, in the above-mentioned embodiment, the automatic running attitude operation and the automatic holizontal operation are effected. In this embodiment, when the fork is stopped at the constant lifting height position in response to the operation of the precision snap-acting switch 398 and the pressure sensor 106 becomes operative, the change-over circuit 514 produces an angle adjusting voltage Vx. The comparator 518 compares the voltage Vx with the voltage Vy proportional to the backwardly inclined angle varying according to the inclined angle α of the upright 10. When the voltage Vy is equal to the voltage Vx, the circuit 518 produces a stop command signal of the tilt cylinder 348. The angle adjusting voltage Vx is adjustable with the adjusting knob 508. As a result, this makes it possible to adjust the angle α of the fork 18 in the running attitude condition with the adjusting knob 508 so as to meet the kinds of the load or the shape thereof.

The present embodiment may be embodied as follows.

(1) Instead of the signal rendered to the change-over circuit 514 by the pressure sensor 106, when there is no load or the weight of the load is very light, the device is designed so that the running attitude control is effected at the desired backward inclined angle.

(2) The fixed resistor 504, the change-over circuit 514, and the push-button switch 246S_1 for controlling tilt cylinder may be omitted. The device is designed so that the voltage Vx of the variable resistor 502 is fed to the comparator 518 when the push-button switch 246S_2 for controlling lift cylinder, the pressure sensor 106, and the precision snap-acting switch 398 are all in operative condition.

(3) An additional running attitude button (not shown) for actuating the precision snap-acting switch 398 is further provided. When it is required to move the fork to the running attitude position, the running attitude push-button switch is actuated so that the precision snap-acting switch 398 is placed in an operative condition to lift or lower the fork with a manual actuating lever. When the fork is moved to the predetermined lifting height position, the precision snap-acting switch 398 is designed to become operative.

According to the third embodiment of the invention, when the fork is moved to the predetermined height suitable for running, the voltage proportional to the backwardly inclined angle of the upright is compared with the voltage for adjusting an angle of the upright is compared with the voltage for adjusting an angle of the fork, and when the former is equal to the latter, the stop command signal for tilt cylinder is produced. Accordingly, this makes it possible to adjust the angle of the running attitude of the fork during the loading and unloading work according to the kinds of the loads and the shape thereof.

Reference is made to the fourth embodiment of the present invention. The feature of the present embodiment resides in that according as the lifting height of the fork increases, the region for adjusting an angle of the running attitude of the fork is narrowed. For this purpose, the voltage proportional to the lifting height of the fork is compared with the voltage proportional to the backwardly inclined angle of the upright, and when the former is equal to the latter, a command for stopping the operation is fed to the tilt cylinder.

The tilting angle device according to the present embodiment will be described with reference to Fig. 14, wherein the same reference numerals used in Fig. 12 denote corresponding parts, respectively.

The microcomputer 230 judges as to whether the fork 18 lifts or lowers and calculates the lifting height value of the fork 18 in accordance with two kinds of pulse signals, each having a different phase, being fed to the rotary encoder 102". The pressure sensor 106 is provided in the hydraulic pressure circuit for the lift cylinder 346. When the hydraulic pressure is above the predetermined value, that is, the load larger than the predetermined weight is mounted on the fork 18, the hydraulic pressure sensor 106 feeds a load sensing signal to the microcomputer 230. The microcomputer 230 judges that the fork is placed in stooped condition due to the two kinds of pulse signals and feeds the calculated lifting height value (digital value) to the D/A convertor 520 in response to the load sensing signal. In the embodiment, D/A convertor 520 is designed so as to produce a lifting height proportional voltage V_1 which decreases as the lifting height value (digital value) of the fork 18 increases. The D/A convertor 520 and the potentiometer 104" are connected to the comparator 518'. The comparator 518' compares the lifting height proportional voltage fed from the D/A convertor 520 with the backward inclined angle proportional voltage V_2 fed from the potentiometer 104" to produce a stop command signal for stopping the actuation of the tilt cylinder 348, when the voltage V_1 is equal to the voltage V_2. The control circuit 264 which supplies the stop signal to the actuator 324 of the control valve 344 for actuating the tilt cylinder 348 is connected to the comparator 518'.

The operation of the fork angle control device thus constructed will be described.

The initial condition of the fork 18 is shown in Fig. 9 by a solid line. In this condition, the lifting height H is 0.2m. The pressure sensor 106 produces a load detecting signal indicating that the weight of the load larger than the predetermined value is mounted to the fork 18. The D/A convertor 520 produces a lifting height proportional voltage V_1 of 6.0 volt labelled by P_1 in Fig. 15. The outer mast 10A is placed in a vertical position. The potentiometer 104' produces a backwardly inclined angle proportional voltage V_2 of 2.0 volt labelled by P'_1 in Fig. 16.

When the push-button switch 246'S_2 for starting automatic lifting height is pressed in this condition, the fork 18 automatically elevates until it reaches the objective lifting height position (for instance, 2m) and then is stopped thereat. In case of need, a push-button switch 246'S_1 for starting automatic holizontally control may be used. As a result, the lifting height proportional voltage V_1 is 3.5 volt labelled by P_2 in Fig. 15. The fork 18 is stopped at the objective lifting height position. When the operating command for tilt cylinder 348 is produced from the microcomputer 2340, the control valve 344 becomes operative due to the output of the actuator 324. As a result, the tilt cylinder 348 becomes operative, so that the outer mast 10A is inclined backward. As a result, the movable terminal 104'T of the potentiometer 104' is rotated. The backward inclined angle proportional voltage V_2 elevates from the above-mentioned 2.0 volt. When the voltage V_2 is 3.5 volt labelled by P'_2 in Fig. 16, the lifting height proportional voltage V_1 (3.5 volt) is equal to the backwards inclined angle proportional voltage V_2. As a result, the comparator 518' feeds a stop command signal to the control circuit 264 to stop the actuator 324. Thus, the control valve 344 is returned to the fully closed position so that the tilt cylinder 348 is stopped. Accordingly, the outer mast 10A is stopped at the position inclined backwards by 5 degree as labelled by P'_2 in Fig. 16.

When the lifting height of the fork 18 is lowered from 2m to 1m by the closing of the automatic lifting height starting push-button switch 246'S_2, the lifting height proportional voltage V_1 is 5 volt labelled by P_3 in Fig. 16. The tilt cylinder 348 moves until the backwards angle proportional voltage V_2 is 5 volt which is the same voltage as that of the voltage V_1 and then is stopped. In this instance, the backward inclined angle α of the outer mast 10A is 10°. This backward inclined angle α is larger than the backward inclined angle (5°) when the lifting height of the fork 18 is 2m.

The fork control device according to the embodiment of the invention is characterized in that a lifting height proportional voltage V_1, which lowers according as the lifting height H of the fork increases is produced by the microcomputer 230, and in that the backward inclined angle proportional voltage V_2 which increases according as the backward inclined angle α of the outer mast 10A becomes large is produced by the potentiometer 104', and in that when the voltage V_1 is equal to the voltage V_2, the comparator 518' produces an a signal for stopping the operation of the tilt cylinder 348. This makes it possible that the backward inclined angle α of the outer mast 10A is controlled so as to become small, according as the lifting height of the fork 18 increases. Further, this makes it possible to eliminate that the gravity center is out of the stable region, thereby improving a safety.

The present embodiment may be embodied as follows:

(1) In the embodiment, the device is designed so as to produce a lifting height proportional voltage V_1 from the D/A convertor 520 on the basis of the calculated lifting height value by the rotary encoder 102" and the microcomputer 230.

Instead of this, the construction may be designed so as to fit a small toothed wheel (not shown) over the chain wheel 12, and mesh a reduced toothed wheel (not shown) with the small toothed wheel, thereby to rotate the movable terminal of the potentiometer (not shown) for producing the lifting height proportional voltage.

(2) The pressure sensor 106 may be omitted.

The fourth embodiment of the present invention is constituted so as to compare the voltage proportional to the lifting height varying proportional to the lifting height H of the fork with the voltage proportional to the backwardly inclined angle and feeds a command for stopping the operation of the tilt cylinder for tilting the upright, when the former is equal to the latter. Accordingly, this makes it possible to narrow the adjustable region for backward inclined angle of the upright, that is, the angle of the fork according as the lifting height becomes high, thereby improving a safety.

Although several preferred embodiments of the

present invention have been illustrated and described, it is believed evident to those skilled in the art that many changes and variations may be made without departing from the spirit and scope of the present invention. Accordingly, the present invention is to be considered as limited by the following claims.

CLAIMS

1. A control device for loading an unloading mechanism adapted to be in a fork lift truck comprising:

a) a sensor unit including a lifting height sensor for measuring a lifting height of a fork, a tilting angle sensor for measuring a tilting angle of an upright, and a load sensor for detecting a weight of a load,

b) a control unit responsive to the output signal of the sensor unit, the control unit effecting a calculation on the basis of the signal therefrom and producing a predetermined control signal according to the calculated value,

c) a servomotor driving circuit responsive to the predetermined output signal of the control unit, and

d) a hydraulic pressure driving circuit producing a control signal for hydraulically controlling a lift cylinder and a tilt cylinder in accordance with the control signal of the servomotor driving circuit,

the improvement wherein

the control unit comprises an interface circuit for inputting the output signal from the sensor unit, and a control command producing circuit comprising a memory for storing a predetermined data in connection with lifting height, tilting angle, or load therein and a data setting means for setting data to said memory,

said control command producing circuit producing a control command on the basis of comparing calculation between the output of the sensor unit and the concerned data stored in said memory to effect an attitude control in accordance with said control command.

2. A control device for loading and unloading mechanism as defined in claim 1, wherein said interface circuit is provided with a lifting height counter for counting the output signal fed from the lifting height sensor.

3. A control device for loading and unloading mechanism as defined in claim 1, wherein said load sensor comprises at least one of hydraluic pressure detecting means and a means for detecting an air pressure of a front wheel of the fork lift truck.

4. A control device for loading and unloading mechanism as defined in claims 1 to 3, wherein said data setting means includes a push-button switch for running attitude command.

5. A control device for loading and unloading mechanism as defined in claim 4, wherein said command producing circuit produces a control command for controlling the tilt cylinder due to the inclined angle preselected by the output signal of said load sensor and the output signal of said tilting angle sensor to effect a holizontally positioning control.

6. A control device for loading and unloading mechanism as defined in claim 5, wherein said control command producing circuit produces a control command so as to lower the fork to the running position due to the output signal of said lifting height sensor after said holizontally positioning control is carried out, and when the fork reaches the running height position, to effect a tilting angle of the upright to the inclined position for running.

7. A control device for loading and unloading mechanism as defined in claims 1 to 5, wherein said tilting angle sensor comprises a potentiometer producing an output proportional to an operating angle of the tilt cylinder.

8. A control device for loading and unloading mechanism as defined in claim 7, wherein said control command producing circuit produces a control command for controlling the lifting and lowering operation of the lift cylinder, after the holizontal or backwardly inclined position is confirmed due to the output signal of said potentiometer.

9. A control device for loading and unloading mechanism as defined in claims 1 to 3, wherein a control circuit provided in said control unit comprises an adjusting means for adjusting the setting tilting angle of the fork according to the kinds of a load or the shape thereof, and a comparing means for comparing an output voltage of said adjusting means with a voltage proportional to the backwardly inclined angle of the tilt cylinder, said control circuit producing a control signal for stopping the operation of the tilt cylinder, when the former is equal to the latter under the condition that the fork is placed in the predetermined lifting height position.

10. A control device for loading and unloading mechanism as defined in claim 9, wherein means for stopping the fork at the predetermined lifting height position comprises a precision snap-acting switch mounted on a stationary part of the upright, and an operating means for operating the precision snap-acting switch when the fork reaches the predetermined position.

11. A control device for loading and unloading mechanism as defined in claims 1 to 3, wherein said control circuit comprises a first means for producing a voltage proportional to a lifting height, a second means for producing a voltage proportional to backwardly inclined angle, and a comparing means for comparing the output of said first means with the output of said second means, the control circuit producing a command for stopping the operation of the tilt cylinder, when the output of said first means is equal to that of said second means.

12. A control device for loading and unloading mechanism wherein the means for feeding a sensing signal indicative of lifting height to the first means comprises a rotary encoder.

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OPD - 1994-03-03

TI - STABILIZATION DEGREE INFORMING DEVICE FOR CARGO HANDLING VEHICLE

IN - NAKANO TAKAHARU

PA - TOYODA AUTOMATIC LOOM WORKS

IC - B66F9/24

TI - Stability indicating device for forklift truck - has information device operated according to control signal from controllers when forklift tends to become unstable

PR - JP19940033786 19940303

PN - JP7242398 A 19950919 DW199546 B66F9/24 010pp

PA - (TOYX) TOYODA AUTOMATIC LOOM WORKS

IC - B66F9/24

AB - J07242398 The indicating device is applicable to forklift (1) which has fork (13)to move either up or down along an inclined surface . It comprises of set of sensors (23a,23b) for detection of tilt angle of vehicle and back and forth tilt angle of a high lifting sensor (14). A fourth sensor (20) is used to detect the tilting angle of a mast (3). An oil pressure sensor is used as a load detector. The data from the sensors are stored in a memory disk. Based on these data and map for stability, the controller judges whether the forklift is in stable state. When the forklift tends to become unstable the controller sends signal to an information machine (44) which lights up to indicate instability in the forklift.

- ADVANTAGE - Cautions operator when forklift tends to become unstable so as to enable him to bring back vehicle to stable position.(Dwg.1/10)

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IN - NAKANO TAKAHARU